50 YEARS 1940–1990

Northern Regional Research Center

1815 N. University Peoria, IL

Agricultural Research Service

FIFTY YEARS OF AGRICULTURAL RESEARCH IN PEORIA

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Welcome to the Northern Regional Research Center! The Center came into being as the result of an Act of Congress in 1938 and its doors opened for the first employees in 1940. We are pleased that you came to celebrate with us the 50th anniversary of that occasion.

We are justifiably proud of the many scientific discoveries and technical successes that have been accomplished during those 50 years, but also of the present research programs that undoubtedly will lead to the new products of the future.

Organizationally, the Center is a part of the Agricultural Research Service of the U.S. Department of Agriculture and administratively it is located in the Midwest Area, one of eight such Area offices in the country.

The Center is managed by the Center Director's Office and 14 Research Leaders who supervise the Research Management Units. The Center employs approximately 150 research scientists and an equal number of support scientists and technicians. Bendix Field Engineering Corporation is the contractor to operate and maintain the facilities and employs an additional 40 people. In total, approximately 400 persons are located at the Center for their employment. Work is mainly directed toward research on present and future field crops. Three main research directions are development of new industrial and food products; food safety, health and nutrition; and plant biochemistry for crop and product improvement.

Because our research is almost exclusively funded from Federal tax dollars, the Center is really yours. Today is your opportunity to see firsthand what we have been and are doing with your taxes. To see everything, just follow the tour route at your own pace. Employees of the Center will be pleased to help you in any way they can. I wish you a pleasant visit and hope that you will become as proud of this Center as we are.

Sincerely,

L. H. Princen

L. H. PRINCEN
Center Director

EXHIBITS FOR NRRC 50TH ANNIVERSARY OPEN HOUSE

Number	Title	Room
1.	Starch-Based Water Absorbent (Super Slurper)	Entry Hall
2.	Starch Product Removes Toxic Metals from Water	Entry Hall
3.	High Fiber, Non-Caloric Flour Substitute	Entry Hall
4.	Kenaf: An Annual Fiber Crop for Pulp and Paper	Entry Hall
5.	Extrusion Laboratory/Twin-Screw Extruder	Pilot Plant
6.	Chemical Conversion of Soybean Oil for Industrial Products	1209
7.	Technicon Autoanalyzer	3200
8.	Computer Applications	3020, 3022
9.	Mycotoxins Defined	3028
10.	Identifying and Controlling Toxin-Producing Molds in Grain	3028
11.	Chemical Analysis of Mycotoxins	3028
12.	Controlling the Production of <u>Fusarium</u> Mycotoxins	3028
13.	Insect Vectors of Molds Involved in Mycotoxin Contamination/Insect Traps	3028
14.	Oils and Fats for the Future	3032
15.	Soybean Oil and Protein in Foods	3034
16.	<u>In</u> <u>Vitro</u> Corn Kernel Culture	Auditorium
17.	Fatty Acid Metabolism in Soybeans	Auditorium
18.	Antinutritional Sugars in Soybeans	Auditorium
19.	Starch Encapsulated Pesticides	Auditorium
20.	Food Proteins and Products	Auditorium
21.	Corn Protein Research	Auditorium
22.	Wheat Protein Research	Auditorium
23.	Jojoba--A New Crop	Auditorium
24.	Improving Yeast by Genetic Engineering	Auditorium
25.	Natural Food Colors from Yeasts	Auditorium
26.	Molecular Taxonomy of Microorganisms	Auditorium
27.	Biological Control of Agricultural Insect Pests	Auditorium
28.	Culture Collection - History and Impact	Auditorium
29.	Useful New Enzyme from a Colorful Fungus	Auditorium
30.	Fiber Effects on Mineral Nutrition in Animals and Humans	Auditorium
31.	EEO Program	3056 (Corridor)
32.	Photosynthetic Oxygen Evolution	3309
33.	Mass Spectrometer	3317, 3319
34.	Increase Utilization of Vegetable Oils Through Biotechnology	2313
35.	Vegetable Oils as Alternative Diesel Fuels for Farm Tractors	2313
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Number	Title	Room
37.	Modern Replacements for Old Tools	2310
38.	Xanthan Gum Research	2305
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40.	Products from New Industrial Oilseed Crops	1300
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42.	Natural Products with Biological Activity	1306
43.	Pheromone Research at NRRC	1312
44.	Computer Modeling of Fats	1313
45.	A Closer Look at the Micro World	1320
46.	Biological Control of Weeds	0317
47.	Fermentation and Bioconversion of Agricultural Materials to Chemicals and New Products	0317
48.	High Pressure Research Laboratory	0326
49.	Starch in Plastics - Injection Molding	0232

SPECIAL EVENTS

Videos — 3062

Highlights of NRRC Research

Slides — 3056

NRRC Research Views, Automatic Advance with Audio

NRRC Chorale — Auditorium

Songs by the Chorale will be presented in the auditorium under the direction of Don Christianson with Mrs. Mary Bradshaw at the electric keyboard. 11:00 a.m., 1:00 p.m., 3:00 p.m., 5:00 p.m.

? NEED ASSISTANCE ?

First Aid? Lost and Found? Special Requests? More Information? Just ask any Hall Guide. A Nurse will be on duty in Room 1010.

EXHIBIT 1
Entry Hall (PPL)

STARCH-BASED WATER ABSORBENT (SUPER SLURPER)

Super Slurper is a starch derivative that can absorb several hundred times its weight of water. It is prepared by first chemically combining starch with about an equal weight of the same plastic used in Orlon production. The resulting composite is then treated with hot alkali to yield the final product. Super Slurper is produced by three companies and is used in seed and root coating formulations, as a moisture-holding agent in soils, and as a water-trapping agent in fuel filters. It is also being tested for use in disposable soft goods, such as diapers.

EXHIBIT 2
Entry Hall (PPL)

STARCH PRODUCT REMOVES TOXIC METALS FROM WATER

Insoluble starch xanthate (ISX) is a starch-sulfur compound used to remove heavy metals from wastewater. ISX is an ion-exchange material produced from corn-starch which is annually renewable and inexpensive. When ISX is added to wastewater containing heavy metals, it binds them instantaneously. The precipitated sludge can be safely disposed of in landfills or it can be treated to allow metal recovery. This patented technology was commercialized in 1980 and the product is presently being made on a farm in Iowa.

EXHIBIT 3
Entry Hall (BPR)

HIGH FIBER, NON-CALORIC FLOUR SUBSTITUTE

Americans consume about half the recommended amount of dietary fiber, according to the National Cancer Institute, despite studies that link fiber-rich diets to decreased risks for colo-rectal cancer and certain other disorders. Dietary fiber is that portion of food that cannot be digested by humans. Because consumers often object to the tastes and gritty textures of foods made from whole grain flours, the fiber-laden bran is usually removed when flour is made from cereal grains. As a result, many of our favorite foods can be high in calories and low in fiber. Scientists at the Northern Regional Research Center have developed a simple treatment process that removes the gritty textures and strong flavors often associated with brans and other materials rich in dietary fiber. The USDA treatment process makes brans softer and more water absorbent, allowing their use in place of some of the flour in baked products such as white bread. Because treated brans have no calories, it is now possible to produce white bread with more fiber and fewer calories than whole wheat bread. Fiber treated by the new process can be added to a wide range of foods without affecting the food's taste, texture, or color.

EXHIBIT 4
Entry Hall (OC)

KENAF: AN ANNUAL FIBER CROP FOR PULP AND PAPER

Scientists at the Northern Regional Research Center in collaboration with plant scientists at Beltsville, MD, Savannah, GA, and other locations studied kenaf and developed several technologies for its use. Kenaf is readily processed to high quality pulps using a variety of techniques familiar to the industry. NRRC scientists found that kenaf chemical pulps are superior to commercial hardwood pulps and, except for resistance to tear, are comparable to softwood pulps. The chemical and physical properties of kenaf fibers show that these fibers should be suitable for numerous applications. Paper machine runs with various kenaf pulps provided from several pounds up to a ton of several grades of paper, including stationery, low-gloss magazine, high-gloss magazine, and newsprint. Newspaper has been demonstrated on a commercial scale, and a private group is proceeding with construction of a $45 million newsprint mill in south Texas scheduled for completion in 1991.

EXHIBIT 5
Pilot Plant (FPC)

EXTRUSION LAB/TWIN-SCREW EXTRUDER

A twin-screw extruder is an apparatus used in the foods, plastics, and rubber industries to mix, react, and extrude various materials under intense, high-solids mixing conditions. The extrusion exhibit displays a commercial extruder with corotating, fully intermeshing twin screws, which is being used to experimentally modify cornstarch for industrial uses. Currently, cornstarch is being reacted with various materials to produce (1) chemicals for urethane foams, (2) starch graft copolymers for water- absorbent materials, (3) starch encapsulated herbicides for weed control, and (4) starch-plastic premixes for blown film.

EXHIBIT 6
Room 1209 (OC)

CHEMICAL CONVERSION OF SOYBEAN OIL FOR INDUSTRIAL PRODUCTS

Although the major use of soybean oil is for food products such as salad and cooking oils and margarine, 200 million pounds are used annually in industrial applications. However, a surplus of 1.2 billion pounds of soybean oil is carried over each year. We would like to expand the use of soybean oil in new industrial products, thus benefiting both farmers and consumers. One way of producing new industrial products is to chemically convert soybean oil to a variety of new chemicals, or to produce known chemicals more efficiently. The chemist makes these products in the laboratory. This station shows a special research tool that consists of a sophisticated computer-controlled high pressure, high temperature reactor. The chemical reactions that occur in this reactor may give a variety of products that can be controlled by special materials called catalysts that speed up the reaction and/or give higher yields of products. Such products may find use as lubricants, fuels, plastics, greases, inks, and cosmetics.

EXHIBIT 7
Room 3200 (ACS)

TECHNICON AUTOANALYZER

Critical in researching and better understanding cereals and foodstuffs is to have accurate knowledge of their chemical and physical properties. The Chemical Analysis Group supports researchers at NRRC and selected Department of Agriculture (USDA) researchers outside NRRC by providing a broad range of analytical services. Among the services provided are determinations of fat, moisture, sugar, dietary fiber, crude fiber, heavy metal, enzyme, ash and fatty acid content of food samples.

On display is our most requested analysis, total nitrogen content. Nitrogen has such a pivotal role in plant growth and development, along with its importance in human nutrition that determining its value can provide a wealth of information. This analysis involves the use of a digestion block and calorimetric analysis unit.

EXHIBIT 8
Rooms 3020, 3022 (ACS)

COMPUTER APPLICATIONS

The Modcomp (Modular Computer Systems) computer is the central scientific data processor for the laboratory. It is connected to many instruments and terminals throughout the building. The computer is used to collect raw data, perform mathematical analyses, produce printed and plotted reports, and store the data. The computer consists of the central processor (CPU), disk drives, magnetic tape transports, line printer, plotter, analog voltage input devices, and digital input-output devices. The computer room, some individual components and two continuous computer-generated presentations will be on display. One presentation will demonstrate gaussian deconvolution and the other will demonstrate the use of mass spectral data.

EXHIBIT 9
Room 3028 (MTX)

MYCOTOXINS DEFINED

Mycotoxins are poisonous chemical compounds produced by fungi (molds) and they can occur as the result of growth of the fungi on grains or other foods and feeds. Some mycotoxins are secreted into the grains and may remain even after commodities are processed. When contaminated foods or feeds are consumed by man and other animals, a variety of diseases may result, depending upon the specific mycotoxin ingested. These diseases may be acute, resulting in sudden death, or may be more prolonged, resulting in poor weight gains, suppression of immunity, or tumors. The goal of the Mycotoxin Research Unit is to determine possible means to control or prevent the contamination of foods and feeds with various mycotoxins.

EXHIBIT 10
ROOM 3028 (MTX)

IDENTIFYING AND CONTROLLING TOXIN-PRODUCING MOLDS IN GRAIN

The process of determining the presence and abundance of potential mycotoxin producing fungi in cereals begins with the microbiological examination of surface sterilized grain. Mold populations in the milled flour are identified and counted using the dilution plate technique. Suspected toxin-producing molds are isolated into individual culture tubes and tested for their ability to produce specific mycotoxins. When a feed is toxic to livestock or poultry, but no known mycotoxins can be detected in samples of that feed, a search begins for a new mycotoxin. The chemical structures of several important mycotoxins, with names and strain numbers of molds producing these toxins, are included in the display.

THE DISEASE CYCLE OF *ASPERGILLUS FLAVUS* IN CORN

Aspergillus flavus is an important mycotoxin producing fungus. It produces tiny yellow-green spores that are carried by wind or insects to corn. The fungus also produces long-lived survival structures called sclerotia. Both types of propagules are associated with damaged corn kernels, and are dispersed onto the ground during combine harvesting. Sclerotia can also form on naturally *A. flavus*-infested maize residues in soil. Buried sclerotia are able to survive overwintering and germinate just prior to silking of corn. We have made substantial progress in understanding the disease cycle of this fungus in nature and are now studying different approaches to control fungal sclerotia and reduce the level of yellow-green spores in corn fields.

EXHIBIT 11
Room 3028 (MTX)

CHEMICAL ANALYSIS OF MYCOTOXINS

This display depicts parts of numerous methods that the Mycotoxin Analytical Team has developed over the past 26 years. The group had its beginning shortly after the outbreak of "Turkey X" disease in Great Britain in 1960 when 100,000 turkey poults died. This problem was found to be caused by potent liver carcinogens which were found in the peanut meal portion of the turkey feed. These carcinogens were named the Aflatoxins, and research scientists at NRRC have made major contributions in the development of analytical methods to measure these and numerous other mycotoxins. Nine methods developed at NRRC by this internationally recognized group are currently the "Official Methods" that are recommended by 4 major industrial organizations for assaying various mycotoxins. The display shows the "BGY" presumptive test for aflatoxin in corn, thin-layer chromatography plates with the fluorescent zones of aflatoxin, high-performance liquid chromatography (HPLC) chromatograms of aflatoxins, and the latest immunochemical test kits that have been developed to test for mycotoxins at the site of possible contamination.

EXHIBIT 12
Room 3028 (MTX)

CONTROLLING THE PRODUCTION OF FUSARIUM MYCOTOXINS

Developing methods to control mycotoxins requires basic knowledge of the way in which fungi produce these toxic substances. The formation of mycotoxins by fungi is frequently the result of a long and complex process. We have been able to determine many of the steps leading to the formation of Fusarium mycotoxins by studying fungi that have been genetically altered so that they no longer make mycotoxins. These fungal mutants have also been used to demonstrate that the production of mycotoxins plays a role in plant diseases caused by Fusarium.

EXHIBIT 13
Room 3028 (MTX)

INSECT VECTORS OF MOLDS INVOLVED IN MYCOTOXIN CONTAMINATION/INSECT TRAPS

Insects are important in carrying fungi that produce mycotoxins. At NRRC we are concentrating on the involvement of sap beetles and low-input measures for their control in corn. In the Midwest, the dusky sap beetle is most important, because it feeds on moldy corn debris and then carries the mold to the developing corn ears. Some existing corn varieties appear to have factors that promote resistance to these insects. Attractants have also been developed for these insects so that they can be monitored or trapped.

EXHIBIT 14
Room 3032 (VO)

OILS AND FATS FOR THE FUTURE

Designer oils will be a common part of your future diet just as designer jeans are found in your wardrobe. Scientists now have the capability to modify soybean and other oil-producing plants to
can now have oils that have
erties or oils that produce
Fifty years ago, NRRC
ve the flavor problem of
n it into the world's most widely used food oil. That research resulted in soybean oil being the ingredient of choice for most frying and cooking oils, salad dressings, shortenings, and margarine in the U.S. We continue that oil research today with the help of sensory panels and state-of-the-art instrumental and chemical analyses to evaluate the end-use quality of a variety of new fats and oils that you will see in our display.

EXHIBIT 15
Room 3034 (VO & PPR)

SOYBEAN OIL AND PROTEIN IN FOODS

Illinois is the number one state in producing soybeans, but are you aware of how soybeans are used in our foods? Soybeans contain 20% oil and 40% protein, but no cholesterol. Through processing, the soybean yields oil, lecithin, soy flour (50% protein), protein concentrate (70% protein), protein isolates (90% protein) and dietary fiber. These food ingredients are used in many products that we eat every day. If you read labels on food items, you will find these ingredients in products such as margarine, salad dressings, cooking oils, prepared mixed, breads, pastries, cake mixes, meat extender, breakfast cereals and dietetic foods to name just a few. Research at NRRC since 1940 has helped to solve many problems that originally confronted the food industry when they tried to use the soybean in foods. These obstacles include flavor, processing methods, color, and other functional properties, and nutritional quality. The net result of our research is that today, the versatile soybean is found in a large variety of consumer products.

EXHIBIT 16
Auditorium (SB)

IN VITRO CORN KERNEL CULTURE

The quality and marketability of corn depends on the composition of storage compounds (starch, protein, fat) in the kernel. This composition can be affected by the transport of sugars and nitrogenous compounds into the kernel during development. To study the

mechanism of transport of substances into the grains, a small piece of cob tissue, bearing kernels, is excised 5 days after pollination and placed in culture on a defined medium. Growth of the kernel and uptake of substances from the medium can be observed under tightly controlled conditions. Another experimental system was developed by crossing tassel-seed corn (Ts-5) with tunicate corn (Tu). The resulting Ts-5 Tu plants produce kernels on the tassel with short stems. This allows removing the kernels without wounding tissues near the kernel base, which is impossible with normal kernels on ears. This system allows study of transport mechanisms by culturing the exercised kernels in various test solutions. Together, these model systems will provide information needed by corn breeders and molecular biologists to develop corn strains with specific alterations in kernel composition and quality.

EXHIBIT 17
Auditorium (SB)

FATTY ACID METABOLISM IN SOYBEANS

Vegetable oils, which furnish a major portion of the fat in the American diet, consist of a variety of saturated, mono-unsaturated, and poly-unsaturated fatty acids. Medical studies over the past forty years have shown that use of oils containing a high content of polyunsaturated fat is beneficial in the prevention of cardiovascular disease. In this project, we are investigating the biochemical processes by which oilseed plants, particularly soybeans, synthesize and store fatty acids. Through this study we hope to identify those processes which produce the highest content of polyunsaturated fatty acids, so that breeding programs can be developed for the purpose of producing such oils. As part of this study, mutant varieties of soybeans are being analyzed in order to identify naturally-occurring varieties which produce higher amounts of polyunsaturated oil.

EXHIBIT 18
Auditorium (SB)

ANTINUTRITIONAL SUGARS IN SOYBEANS

Soybeans contain a class of indigestible sugars, commonly called raffinose saccharides, that contribute to the poor feed efficiency of soy meals. Removal or reduction of these antinutritional sugars in soybeans will allow animals to obtain more energy and nutrients from the meal, consequently benefiting soybean and livestock farmers, as well as consumers in millions of dollars annually.

At the Northern Regional Research Center, we are investigating procedures for the purification of galactinol and galactinol synthase. Galactinol synthase is the unique enzyme which potentially controls the formation of raffinose saccharides. Purification of this enzyme to homogeneity is the first major step toward the reduction or elimination of these indigestible sugars from soybeans through future genetic engineering. We also collaborate with scientists at the USDA Germplasm Collection Centers in an attempt to select soybean varieties useful for breeding soybeans low in raffinose saccharides.

EXHIBIT 19
Auditorium (PPL)

STARCH ENCAPSULATED PESTICIDES

Encapsulation of chemical herbicides and insecticides in a starch matrix is a good way to keep the chemical pesticides where applied. This technique of providing controlled-release formulations greatly reduces losses of pesticide due to volatility, leaching by water, and decomposition by light. Since the pesticide stays where targeted, it is used more efficiently and any negative impact on nontarget organisms and the environment is greatly reduced.

This summer large quantities of starch encapsulated herbicides are being evaluated in a 9-state field study against commercial formulations to compare weed control and to show reduction in groundwater contamination.

A patented process using starch for encapsulation is effective also in protecting flavors, drugs, nutrients, etc. for use in foods and feeds.

Bacteria and viruses that kill pest insects are also ideal candidates for the starch encapsulation process. These live pathogens quickly die in the field and must be protected

to be effective control agents. Also, insects must eat the pathogens to become infected. Formulations can be assembled to protect these agents and, at the same time, make the pathogens attractive to insects. Work in cooperation with interested companies is in progress to bring this phase of the technology to market.

EXHIBIT 20
Auditorium (PPR)

FOOD PROTEINS AND PRODUCTS

Proteins are essential in human diets, and can be incorporated into many food products. This display will show several recent developments, including (1) CSM, a nutritious blend of corn, soybeans, and milk for export; (2) a frozen milk concentrate formulated from nonfat dry milk, water, and vegetable oil; (3) food products including protein recovered from corn stillage after converting starch to alcohol; and (4) foods prepared from different corn milling streams.

EXHIBIT 21
Auditorium (PPR)

CORN PROTEIN RESEARCH

There are many different types of corn plants, and many uses for their grain in feeds and food. Some types of corn have been developed that are more nutritious--these sometimes are too soft, however, or may break, or have poor milling properties. Breeders have responded by developing new lines having both good nutritional properties and hard kernels. We study the proteins of these types of corn to improve our understanding and use of these kernels. This display will show some methods we use to analyze corn proteins, including a turbidity test for zein, electrophoresis, and chromatography. These tests are explaining how proteins influence corn quality.

EXHIBIT 22
Auditorium (PPR)

WHEAT PROTEIN RESEARCH

Wheat is one of our most important food crops. There are several types of wheat, including hard wheat (which makes bread), soft wheat (for cakes, crackers, and cookies), and durum wheat (for spaghetti and macaroni). This display will show how wheat is milled, and typical products made from each wheat type. Wheat's elastic gluten proteins are very important in these products. We will show how we study these proteins, using methods such as high-performance liquid chromatography. Our results help explain how gluten influences wheat quality, and provide information that helps breeders develop new varieties.

EXHIBIT 23
Auditorium (NC)

JOJOBA--A NEW CROP

Jojoba is a new crop that grows in desert areas. It is bushy and grows to 6 to 8 feet tall in 6 years. The major product from jojoba is its unique seed oil. Until 1972, U.S. industry used sperm whale oil in many lubricants. Congress banned sperm whale products in 1972 to stop the killing of whales. Jojoba oil is almost identical to sperm whale oil. Chemists call the oil a liquid wax ester, and 60% of jojoba seeds is this liquid wax ester. More than half of the U.S. produced jojoba oil is exported to Japan and Europe which helps our balance of payments. You will receive a small sample of jojoba oil. It softens the skin and is used in cosmetics and skin treatments worldwide.
Even with the excellent oil from jojoba seed the farmers of jojoba needed help. After the oil was extracted, the rest of the seed was being buried in landfills. The "seed meal" as it is called was high in protein but also contained natural products that kept cattle from growing well on the feed. In the last 3 years, scientists at NRRC have developed methods to convert this wasteful by-product into a useful animal feed. Other new products from jojoba seed meal are currently being developed.

EXHIBIT 24
Auditorium (MP)

IMPROVING YEAST BY GENETIC ENGINEERING

Yeasts possess a wide variety of biochemical processes that are of scientific and commercial

importance. Our primary interest is in developing new ways to transform (genetically alter) yeasts that have new and useful fermentation abilities utilizing agricultural material such as corn starch and soybean oil. Transformation is a process whereby new genetic information, in the form of "naked" DNA, is transferred into a living cell, which can then use the added genetic material to carry out a new function. The ability to modify yeasts by adding extracellular DNA is an important advance that provides avenues for understanding or changing the biochemistry of the organism and the development of commercially useful strains. To date, only a few transformation systems have been developed for yeasts other than the common baker's yeast Saccharomyces cerevisiae. Foremost among the requirements for developing new trans-formation systems is a means by which new DNA can be delivered to the cell. Some yeasts possess small pieces of DNA, known as plasmids, that are self- reproducing and can be used as carriers, or vectors, of new genetic information into other organisms. These plasmids are usually circular molecules. We have screened a large number of yeasts for the presence of plasmids and have identified several strains that carry unique linear DNA plasmids. Linear DNAs appear to be the most frequent type of plasmids in yeasts and they occur in a number of different species. This attribute combined with the fact that the linear plasmids appear to be very stably maintained at many copies per cell makes these molecules prime candidates for use as vectors. Our studies are designed to understand the biology of these linear plasmids and to use them as vectors in the development of new transformation systems.

EXHIBIT 25
Auditorium (MP)

NATURAL FOOD COLORS FROM YEASTS

Recently, there has been increased commercial interest in the use of pigments in animal feeds and food dyes. Many foods owe their color to the presence of carotenoid pigments. Over 200 different naturally occurring carotenoids have been described.

Carotenoids are important and expensive components of aquaculture feeds where they provide aesthetically necessary color for consumer acceptance of salmon, shellfish, sea trout, etc. and may contribute to unique flavors as well. Farm rearing of fish is an expanding industry. Salmon rearing alone has increased from about 10,000 metric tons in 1978 to more than 150,000 metric tons in 1987. An increase to greater than 200,000 metric tons is expected by 1990.

Presently, shrimp shells, krill, etc. are used to supply this pigment requirement but high bulk and ash levels make these sources undesirable. Extraction of pigment is not a feasible alternative because of cost. Astaxanthin, a carotenoid from yeast, imparts red coloration to trout meat and may be an economical alternative. Phaffia rhodozyma is unusual among pigmented yeasts because it synthesizes astaxanthin as its principle carotenoid. Our studies are designed to understand astaxanthin biosynthesis in P. rhodozyma and develop a means to improve astaxanthin synthesis by genetic engineering.

An added benefit of dietary supplementation of foods with carotenoids (such as canthaxanthin) is that they may lower the rates of certain cancers in humans. Both the National Cancer Institute and the American Cancer Society have recommended diets that include foods rich in beta carotene. The NCI is currently sponsoring 14 large-scale, long-term studies to evaluate beta carotene as a potential cancer inhibitor. The use of closely related carotenoids in foods may also be of value as canthaxanthin has been shown to inhibit neoplastic transformation in cultured mammalian cells and to cause regression of oral carcinomas in humans when administered by local injection.

EXHIBIT 26
Auditorium (MP)

MOLECULAR TAXONOMY OF MICROORGANISMS

Correctly identifying different microorganisms is an essential part of guaranteeing purity and wholesomeness of commodities and foods, and in quality control of industrial processes which range from antibiotic production to food supplement manufacture. However, the distinctions between useful and harmful organisms are sometimes difficult to see.

Molecular taxonomy of microorganisms provides a means for rapid and accurate identification of microbes.

The genetic material of each species contains molecular sequences which uniquely identify the organism. We are determining the parts of the genetic material that contain unique sequences through DNA sequence analysis of a particular gene. Variants of this gene, which possess unique sequences, are found in all microorganisms. The identification of specific sequences in organisms provides the groundwork for the subsequent development of molecular probes. Probes are effective for rapid identification of species and will significantly improve our ability to recognize microbes and control their presence in commodities and manufacturing processes.

EXHIBIT 27
Auditorium (MP)

BIOLOGICAL CONTROL OF AGRICULTURAL INSECT PESTS

Growing concern exists about the environmental safety of synthetic chemical pesticides. Biological control of pests may prove to be a useful alternative or adjunct to chemical control. Scientists at NRRC are studying, on a molecular level, how certain fungi act as natural enemies of insects. This work may one day provide farmers with new and improved strains to safely control pests. Portions of this project are supported by the Biotechnology Research and Development Corporation, headquartered within the Northern Regional Research Center.

EXHIBIT 28
Auditorium (MP)

CULTURE COLLECTION--HISTORY AND IMPACT

The Agricultural Research Service Culture Collection (NRRL) is one of the world's largest collections of molds, yeasts and bacteria. The approximately 80,000 cultures in the collection are of agricultural and industrial importance and have been used in research on penicillin and other antibiotics, riboflavin (a B vitamin), xanthan and dextran gums, and more recently food fermentations, mycotoxins, and biomass conversion.

Penicillin production was developed at this laboratory by a team of chemists, biochemists and microbiologists working during World War II. That work won the NRRC international acclaim. Subsequently, a yeast was identified that produces large amounts of the essential vitamin riboflavin for industrial production. Later, a search successfully found a microorganism which would produce dextran, a compound used as a blood extender in hospital emergency rooms. During the 50 years in which the NRRC has operated, many other microbes have been identified which economically produce organic acids and a host of high value organic compounds.

Still other work has concerned the fungi that form mycotoxins in corn, peanuts, cereal grains and other foodstuffs, and the microbiology and biochemistry of fermented foods. Biomass conversion research found ways to make useful products from agricultural commodities and agricultural wastes. Current work centers on the production of environmentally sound pesticides, natural food dyes, and methods for the rapid identification of harmful or toxin producing fungi in commodities.

Exhibit 29
Auditorium (MP)

USEFUL NEW ENZYME FROM A COLORFUL FUNGUS

Brightly pigmented tropical yeasts were discovered to produce an exceptional new form of the enzyme "xylanase". This enzyme rapidly breaks down plant fiber found in agricultural residues such as wheat straw and corn cobs, providing a potential means to biologically convert these waste materials into useful chemicals. The new enzyme may also be useful in the processing of foods such as fruit juices, and in the treatment of wood pulp to produce high-quality fibers for paper and rayon. Scientists at NRRC are investigating, on a molecular level, how this novel enzyme achieves its high level of activity.

EXHIBIT 30
Auditorium (FPC)

FIBER EFFECTS ON MINERAL NUTRITION IN ANIMALS AND HUMANS

Our research program is addressing the problem that some dietary fiber sources have the ability to bind nutritionally important minerals such as calcium, zinc and iron. This means that in a high fiber diet, even though these essential minerals are present in the diet, an important proportion may be absorbed by the fiber and thus not be available for the body to use. This could be a problem for those who consume large amounts of fiber. Since dietary fibers are different, we have measured the mineral absorption capacity of a variety of fibers, wheat bran, oat hull, corn bran and soybean hull. We have used the Center's x-ray microscope to determine the extent of absorption of these important minerals onto fiber as the fiber passes through the gastrointestinal tract of pigs, which have digestive systems similar to humans. Computer modeling is used to interpret the results of these studies so that guidelines can be developed for dietary mineral requirements in high fiber diets.

EXHIBIT 31
Room 3056 - Corridor

EEO Program

We are an equal opportunity employer. The exhibit informs the general public of the various job opportunities in the Federal Government and provides information on talents and skills necessary to obtain federal jobs. As an equal opportunity employer, our only criterion for employment is ability.
Pictures are shown representing various groups of people employed by the Federal Government. Pamphlets and handouts are available with regard to careers in the Federal Government.

EXHIBIT 32
Room 3309 (PB)

PHOTOSYNTHETIC OXYGEN EVOLUTION

The biophysical reaction whereby plants convert light energy into useful chemicals is called photosynthesis. The photosynthetic reaction is actually two separate photoreactions: one removes electrons from water to generate oxygen and to provide energy for other chemical reactions; the other converts carbon dioxide into carbohydrates (sugar and starch). Research at NRRC focuses on the oxygen evolving photoreaction, which is important from the standpoint of practical concerns for health, productivity, and the environment.

Oxygen evolution in plants is sensitive to many environmental stresses such as high or low temperature, high salinity, intense visible or ultraviolet light, and drought. This reaction distinguishes plants from other forms of life, and is also the site of action for about half of the known herbicides. Detailed knowledge of how plants use light energy at the molecular level will help in the future design of more efficient plants and improved ways to exploit differences between plants and other living organisms. Research at NRRC thus provides answers to both practical and theoretical questions related to the plant photoreaction that generates oxygen.

EXHIBIT 33
Rooms 3317, 3319 (VO)

MASS SPECTROMETER

The mass spectrometer is a large electronic instrument that measures the mass of atoms and molecules by the use of electric and magnetic fields. Components of soybean oil, products from chemical reactions, and derivatives from human blood and tissue samples are injected into the instrument and identified by their mass or by the pattern of their breakdown products. For example, the mass spectrometer is used to analyze deuterium isotope labeled products from our human studies on the metabolism of dietary fats. Three mass spectrometers and their computers will be on display.

EXHIBIT 34
Room 2313 (OC)

INCREASE UTILIZATION OF VEGETABLE OILS THROUGH BIOTECHNOLOGY

Another approach to preparing industrial products from surplus soybean oil is through biotechnology. This research aims at converting soybean oil into new chemicals by use of enzymes. Enzymes are special chemicals produced by all living organisms that affect essential chemical changes. For this research project, our enzymes have been obtained from microorganisms such as bacteria or yeasts. Either microorganisms or the extracted enzymes have been used to convert vegetable oils into new chemical products. Certain enzymes can rearrange the components of vegetable oils to give new physical properties and thus provide for expanded uses of these oils. Other enzymes have been found that break down vegetable oils into fatty (long carbon chain) acids and glycerol, a 3-carbon alcohol. These oil-derived substances may be further modified by different enzymes to produce new products that may have industrial application. Examples of these applications include such products as cosmetics, lubricants, coatings, detergents, plastics, and chemicals for manufacturing other useful products.

EXHIBIT 35
Room 2323 (OC)

VEGETABLE OILS AS ALTERNATIVE DIESEL FUELS FOR FARM TRACTORS

The oil embargoes of the 1970's threatened to deprive the American farmers of diesel fuel to run their tractors. To avoid this situation in the future, research was begun at this Center to investigate the feasibility of using vegetable oils or chemicals derived from them as fuels during emergencies. Vegetable oils performed well in diesel engines in short term testing. However, extended use of these oils presented serious problems due to incomplete combustion, which is caused, in part, by the high viscosity (thickness) and high boiling points of vegetable oils. Several approaches to solve the problems of incomplete combustion and therefore improve engine durability include: 1. Chemically converting the vegetable oils with alcohols to simpler chemicals called fatty esters; 2. mixing vegetable oils with alcohols to form stable blends called microemulsions; 3. dissolving vegetable oils in diesel fuel; and 4. heating the vegetable oils to break them down to a variety of lower-boiling chemicals. Despite these improvements, the problem of incomplete combustion remains largely unsolved. We are conducting fundamental studies that will give a better understanding of the combustion chemistry. With that information, we plan to design technologies that will improve the combustion process.

EXHIBIT 36
Room 2311 (BPR)

COLOR VIDEO MICROSCOPE

Much of our work involves microscopy and, as the old adage goes, "one picture is worth a thousand words". Our microscope which is equipped with a color video adapter and a 35-mm camera provides a great advantage. Enlarging the image from the microscope on the video monitor allows for group discussions regarding the sample of interest. If there is an image on the monitor that we wish to save, then all we have to do is freeze the frame and make a print from the screen. These prints can then be saved in our notes. With the 35-mm camera, we can also make slides (color or black and white), as well as prints.

EXHIBIT 37
Room 2310 (BPR)

MODERN REPLACEMENTS FOR OLD TOOLS

Modern biochemical research depends heavily on scientific instruments and laboratory equipment. These are used to prepare samples, analyze, weigh, and make physical measurements. Since the Northern Regional Research Center was opened 50 years ago, great technical advances have been made in the design and manufacture of these tools of science. We will have on display some of the instruments and other pieces of equipment used in our laboratories in the past, along with

their modern counterparts, to show how some of them have changed over the years. The most obvious advances have come about as a result of the electronic revolution, and can be seen in today's computerized, miniaturized instruments.

EXHIBIT 38
Room 2305 (BPR)

XANTHAN GUM RESEARCH

Xanthan gum is a polysaccharide produced by the microorganism Xanthomonas campestris. Several properties of this polysaccharide make it ideal for many industrial and food purposes, most of which relate to its ability to produce very viscous solutions at relatively low concentrations. In foods it is useful as a thickening agent and emulsifier, and has the added benefit of being non-caloric. Dilute solutions of xanthan gum flow well either hot or cold. A potentially large market for xanthan gum exists in oil field drilling and recovery procedures, where solutions of xanthan gum can be injected into the ground to displace oil toward production wells much more efficiently than water alone.
This display will demonstrate how xanthan can be produced in the laboratory, and will show what purified xanthan gum looks like. Methods for xanthan gum characterization will also be shown.

EXHIBIT 39
Room 2301 (PB)

MANIPULATING GENES TO
IMPROVE PLANTS

The history of agriculture is a story of domesticating and changing plants to suit human needs. Thus, we now have pest resistant varieties with improved yield, and enhanced nutritional quality as a result of careful selection and crossing of crop plants by classic breeding techniques. But new methods for exploiting plants and botanical resources are becoming important as demands on agriculture grow and as the world looks for ways to reduce dependence on petroleum and coal. This presentation will relate how molecular biology in basic research to gain a better overall understanding of plant lipid synthesis has led to the development of a gene that may someday allow the engineering of plants that produce more oil or oils that contain higher levels of specific fatty acids. Demonstrations of some tools and methods employed by molecular biologists in this work will be provided.

EXHIBIT 40
Room 1300 (NC)

PRODUCTS FROM NEW INDUSTRIAL
OILSEED CROPS

New crops produce potentially useful seed oils. We have made products that show the unique properties of these oils. Lesquerella, a desert crop, produces an oil similar to castor oil. We have extracted the oil from the seed and made industrial greases from its components. The oil from Cuphea seed, collected in the Peoria area has a seed oil with many of the same uses as coconut oil. This oil can be made into soaps, detergents, and lubricants. Another plant, meadowfoam, native to Oregon and Northern California, produces a seed oil with fatty acids that lend themselves to the making of lubricants and other rubber enhancers. Nylons and other products can be made from crops such as crambe and industrial rapeseed that make a long-chain acid called erucic acid.

EXHIBIT 41
Room 1304 (BC)

NATURAL GERMINATION INHIBITORS

Research in this unit is aimed at the isolation, purification and identification of natural plant growth regulators and the evaluation of these compounds for commercial use. It is well known that plants compete for light, water and nutrients. Less well established is the natural chemical competition that they undergo; this competition is known as allelopathy. Many plants release compounds into the environment that are toxic to neighboring plants (even those of their own species). These compounds may be transported by water through the soil (leaching) or, if they are volatile, by the wind. While basic research into plant-plant chemical competition provides insight into the complexity of nature, the ultimate goal of our research is to provide new herbicides that are

less harmful to the environment than some that are currently in use. This goal can be reached by learning how to produce the natural compounds or by designing synthetic analogs that take advantage of processes that we observe occurring in the field. Knowledge gained from this research has potential to control a variety of post-harvest food safety and spoilage problems. For example, natural products could serve as safe fungal and bacterial inhibitors in stored grains and vegetables. Experiments now underway indicate that certain compounds that are already in our food supply may be excellent sprout inhibitors for potatoes.

EXHIBIT 42
Room 1306 (BC)

NATURAL PRODUCTS WITH BIOLOGICAL ACTIVITY

Plants, like humans, have chemical defense mechanisms to protect them from microbial infections. In a plant, a microbial infection may cause a hypersensitive response which may include the production of secondary metabolites known as phytoalexins. These compounds display antimicrobial activity and are only produced by the plant when it is stressed. This implicates these compounds as part of the chemical defense mechanism of the plants that produce them. The goal of this unit's research is to evaluate the biological activity of these phytoalexins for potential agrochemical or pharmaceutical uses.

To successfully evaluate the activity of these phytoalexins, first large quantities of the compounds must be elicited, isolated and then assayed in a wide range of biological activity screens. These results are then developed further by analog synthesis and additional activity screening. Finally the structural-activity relationships are investigated by studying each compound structure through computer based molecular modeling.

EXHIBIT 43
Room 1312 (BC)

PHEROMONE RESEARCH AT NRRC

Insects produce natural chemicals called pheromones that are used for "communication" between individuals. Most kinds of moths and beetles, for example, attract mates through the use of pheromones. These chemicals are exceptionally active--a few billionths of a gram of the proper compound is often sufficient to attract an insect. Each species of insect can be expected to have its own, unique pheromone. Pheromones have great potential for environmentally safe pest control. They are extremely active even in tiny amounts, are very specific for a certain kind of insect, and furthermore, have very low toxicity. One tactic is to permeate the air with pheromone, thereby "confusing" the pest insects and preventing them from finding the opposite sex and reproducing. Another approach is to combine the pheromone with a small amount of insecticide, allowing the pest species to be controlled with far less insecticide than usual and with less harm to other organisms.
At NRRC, we have been studying the pheromones of a family of small beetles known as "sap beetles". These insects occur worldwide and are economic pests in a wide variety of fruit and row crops. They are also able to transmit plant diseases such as oak wilt. The tiny amount of pheromone present in each individual required us to use sophisticated equipment for chemical analysis, but the beetles were found to possess a whole family of chemicals which were new to science. Now that the chemical structures are known, large amounts of the compounds can be produced synthetically, making a new tool available for managing these pests.

EXHIBIT 44
Room 1313 (PB)

COMPUTER MODELING OF FATS

Fats, lipids, triglycerides, hydrocarbons--molecules that contain large proportions of carbon and hydrogen--are crucial to life. They are critical components of all life forms, and to inanimate products they contribute properties that add dimension to living and make our life-style more healthy, comfortable and enjoyable. They add texture and palatability to our food, quality and value to our entertainment and household goods and performance to our cleaning agents and our

machinery. Each application works best if the fat fits the task. For example, nutritionists tell us that for dietary purposes unsaturated fats are good and saturated fats are not so good. But in automotive crankcases oil and transmission fluids, the opposite is best.

Fat molecules are able to perform many different tasks because they contain long chains of carbon atoms that tend to associate with each other and thereby form larger molecular aggregates. Due to their chemical structures, the chain of carbon atoms in saturated fats tend to be straight while those in unsaturated fats are bent. In addition, fat molecules can take on different shapes and dimensions that can change easily depending upon conditions under which the fat is used. Thus chocolates that are solid in the box melt in your mouth. This ability to assume many different forms makes fats useful, but it complicates fitting the fat to the task.

Chemistry by computer modeling is being developed to reduce experimentation necessary to match fat molecules and tasks. Armed with modeling software and knowledge of properties that are needed, the chemist can build molecules atom by atom, change molecular shapes, move molecules, and determine if their shapes and packing will provide the properties needed in a particular task. New and unusual structures can be examined easier and in greater detail by computer than by other methods. As knowledge is developed on how computed models relate to the properties of fat molecules, the computer chemist should ultimately be able to identify the optimum molecules for specific tasks. Perhaps you may someday say, "the best fat I ever ate came from a computer."

EXHIBIT 45
Room 1320 (ACS)

A CLOSER LOOK AT THE MICRO WORLD

The scanning electron microscope is a highly complex instrument that is used to look at the surface of objects at magnifications as high as 200,000 times. Unlike the optical microscope which almost everyone has used in science or biology class, the scanning electron microscope uses a high-energy beam of electrons to form an image instead of ordinary light.

The image produced by the scanning electron microscope is much like the picture on a television set. The electron beam, which is formed by applying a very high voltage to a heated tungsten filament inside the microscope, is made to scan back and forth over the sample. Interaction between the beam and the surface of the sample creates tiny electrical signals that are collected and sent to a cathode ray tube (TV screen), where the image is formed from the thousands of points of light as these signals affect the phosphors on the screen. Photographs can be made of the image for a permanent record.

The scanning electron microscope is very useful in determining surface structure of all solid materials. It can be applied to studies of paint, paper products, and microorganisms such as molds, yeasts, and bacteria.

Our scanning electron microscope will be in operation, and a photographic exhibit will illustrate what things look like under the magnifying power of this instrument.

EXHIBIT 46
Room 0317 (FB)

BIOLOGICAL CONTROL OF WEEDS

In the United States alone, it is estimated that weeds account for yield losses exceeding 10% of the potential agricultural crop value, or more than 14 billion dollars. When weeds are effectively controlled, value is added to the crop both through yield increases and through quality increases associated with crop products free of contaminant weedy plant and seed matter.

At the NRRC, we are developing methods for controlling noxious weeds by infecting them with naturally occurring fungal pathogens. Using fungal plant pathogens as "bioherbicides" against weeds has many advantages including effectiveness against weeds which are difficult to control with chemical herbicides, minimal to no damage to nontarget plants and minimal environmental impact.

We have on display the weeds hemp sesbania (Sesbania exaltata) and sicklepod (Cassia obtusifolia) which have been killed or severely reduced in growth due to being infected by the

fungal plant pathogens Colletotrichum truncatum and Alternaria cassiae, respectively. Though bioherbicides are virtually harmless to man, you can see that statement doesn't necessarily apply to weeds.

EXHIBIT 47
Room 0317 (FB)

FERMENTATION AND BIOCONVERSION OF AGRICULTURAL MATERIALS TO CHEMICALS AND NEW PRODUCTS

The conversion of agricultural materials into useful chemicals has historically taken on many forms. In the past, fermentations have centered on the production of solvents and alcohols, particularly as an alternative to their production from petroleum. Recently, the emphasis has shifted somewhat to the development of novel fermentation strategies. It is hoped that these approaches will result in the generation of new products from agricultural commodities (e.g. corn) or offer more efficient conversions than are currently employed commercially. For example, methods are currently being developed to more economically generate acetic acid from the fermentation of corn for the production of calcium magnesium acetate, a non-corrosive road deicer. On display here in the fermentation laboratory are the fermentors and monitoring equipment where new methods can be tested, and products from these types of fermentations.

EXHIBIT 48
Room 0326 (FPC)

HIGH PRESSURE RESEARCH LABORATORY

In this laboratory high pressure technology is applied to solve a variety of problems important in the processing and utilization of agricultural materials. Current work is directed particularly to the exploitation of the unexpected solvent power of carbon dioxide (CO_2) under high pressure conditions where the CO_2 becomes a "supercritical (SC)" fluid. SC-CO_2 can extract oils from a variety of oilseeds, providing a safe alternative to hazardous, flammable, and explosive petroleum solvents used commercially. The utility of SC-CO_2 in extracting flavors, aromas, pigments, has been demonstrated. The technology is being developed and applied to the extraction and analysis of toxicants in foods, avoiding the extensive use of organic solvents whose use can be hazardous and which, when used extensively, present an environmental disposal problem which does not exist with CO_2.

EXHIBIT 49
Room 0232 (PPL)

STARCH IN PLASTICS--INJECTION MOLDING

Starch, a type of natural polymer produced by many plants, may be combined with synthetic petroleum-derived polymers to produce plastic materials with different properties than the pure polymers possess. Starch-synthetic plastic materials may degrade more rapidly, if carelessly discarded as litter, than pure synthetic materials. Faster decomposition of litter would reduce danger of entrapment of wildlife and lessen clutter in the landscape. Test samples of starch-plastic materials are prepared in the polymer processing laboratory by methods such as injection molding.

EXIT TO PARKING LOT

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RESEARCH UNIT	ABBREVIATION
Analytical Chemistry Support	ACS
Bioactive Constituents Research	BC
Biopolymer Research	BP
Fermentation Biochemistry Research	FB
Food Physical Chemistry Research	FPC
Microbial Properties Research	MP
Mycotoxin Research	MTX
New Crops Research	NC
Oil Chemical Research	OC
Plant Biochemistry Research	PB
Plant Polymer Research	PPL
Plant Protein Research	PPR
Seed Biosynthesis Research	SB
Vegetable Oil Research	VO

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